COMPARATIVE TESTS OF THE 100-INCH AND 60-INCH REFLECTORS

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The following paragraphs describe briefly various comparative tests of the two large reflectors of the Mount Wilson Observatory, which have been made for the purpose of determining to what extent the 100-inch Hooker telescope realizes the theoretical gain over the smaller instrument corresponding to perfect figure and ideal atmospheric conditions.

The data for the spectrographic comparison have been derived from plates taken as a part of the regular program of observations, supplemented by a few special photographs. In the case of spectrograms which were not made and developed simultaneously, the number is sufficient to eliminate accidental differences so thoroly that the tests may be regarded as reliable.

The comparisons of limiting magnitude and resolution are from special series of photographs. The number of plates is not large, but the precautions taken to secure comparability are such as to make the results representative.

Spectrographic Tests

The spectrographs in use with the two reflectors at the Cassegrain focus are alike as regards aperture, focal length of camera and collimator and dispersion. Accordingly the results obtained with them are strictly comparable when equal slit widths are used, except for the fact that the spectrograph on the 60-inch reflector contains a plane mirror placed in the optical train between prism and camera lens. Since this mirror is enclosed in the prism box and so protected from dampness and other causes which produce tarnish, its surface remains bright for long intervals of time, and its coefficient of reflection should be close to the theoretical value of 90 per cent for the portion of the spectrum used.

Comparisons of the relative exposure times with the two telescopes have been made in three ways:

1. Simultaneous exposures upon the same stars.

2. Spectrograms of the same stars taken at different times but under similar conditions of seeing.

3. Spectrograms of different stars of known magnitude and spectral type under similar conditions of seeing.

The material available for the third comparison is much larger than for the other two.

The exposure times for the same stars observed with the two instruments have been compared directly. In the case of the other stars the magnitudes have been reduced to the photographic magnitude corresponding to Ko, and the logarithms of the exposure times have been plotted against these magnitudes. The resulting curves should, of course, be straight lines.

The following summary shows the results of the comparisons:

	Seeing	Ratio 100-inch to 60-inch
Simultaneous exposures on same stars	4—5	1:2.9
Exposures on same stars but not simultaneous	5	1:2.6
	Seeing	**Gain of 100-inch**
Exposures on different stars	6	1.0 mag.
Exposures on different stars	4—5	0.9

Combining these results on the usual basis of a difference of three in exposure time for a difference of one magnitude in brightness, we find 0.94 mag. as the gain of the 100-inch reflector over the 60-inch. With an allowance of 10 per cent for the loss of light due to the mirror in the spectrograph of the 60-inch telescope, we obtain a final value of 0.85 magnitude.

Under conditions of very poor seeing the gain with the 100-inch reflector is much reduced. The longer focal length, 135 feet as compared with 80, produces larger images, and the effects of atmospheric disturbances are increased by the greater aperture. For what may be considered as average seeing, however, 4 to 5 on a scale of 10, the comparison shows that the theoretical gain of 1.12 mag. is very nearly realized.

Limiting Magnitude

To test the two instruments for limiting magnitude, several series of photographs have been made under identical conditions with the assistance of Messrs. Hubble and Duncan. Equal exposures were made simultaneously with the two telescopes to the same field, using plates from the same box, which were afterwards developed in the same tray. To eliminate the influence of accidental variations in the sensitiveness of the plates, two or more photographs of the same field were made in each series.

Date	Exp.	100-inch			60-inch			Gain
		Images	Seeing	Limit	Images	Seeing	Limit	
1920, May 22		Large, Sl. El.	5	18.36	Excellent	6	17.82	+0.54
	3	Large, El.	5	17.84	Sl. El.	6	17.42	+0.42
	3	Large, Sl. El.	5	17.83	Good	6	17.61	+0.22
Aug. 14	2	Good	4	17.67	Sl. El.	4	16.88	+0.79
	2	Good	4	17.64	Good	4	16.82	+0.82
	2	Good	4	17.65	Good	4	16.85	+0.80
Aug. 15	2	Good	6	17.75	Poor, El.	6	16.67	+1.08
	2	Good	6	17.80	Sl. El.	6	16.88	+0.92

May 22 Not representative of the performance of the 100-inch. Images very large as compared with those of Aug. 14 and 15. Mirror astigmatic; figure of 60-inch excellent.

Aug. 14. A fair test of both instruments. Note consistency of limits.

Aug. 15. Gain for first pair too large because of poor images on 60-inch plate. The second pair is a fair comparison.

The results for limiting magnitude are shown in the accompanying table. All the photographs were on Seed 30 plates, exposed to Selected Area 87 for which the photographic magnitudes on the normal scale, referred to the international zero point, are well determined. The limit was obtained by selecting 10 or 12 stars on each plate, just faintly visible, and estimating in tenths of a magnitude the interval separating their images from the limit. The known magnitude, plus the estimated interval, thus gives for each star a value of the limit. The tabular values are mean results for each plate. The probable error arising from the estimates is 0.03 or 0.04 magnitude.

For a 2^m exposure on Seed 30 plates we may accept as representative

Seeing	100-inch	60-inch	Gain
4	17.6^5	16.8^5	0.8 mags.
6	17.8	16.9	0.9

Here again, in comparison with the theoretical limit corresponding to ideal conditions, the gain is very satisfactory.

Resolving Power

A similar plan was followed in the tests of resolution, the fields in this case being the central part of the extended nebulosity M 8 and the planetary nebula N.G.C. 7009 which is especially rich in fine delicate detail. One pair of plates on the Ring Nebula in *Lyra* was also made, but the 100-inch plate is defective thru faulty guiding. Of M 8 seven pairs of plates were made with exposures of from 3^m to 15^m, the seeing ranging from 3 to 5 on a scale of 10. N.G.C. 7009 was photographed on a single pair of Seed 23 plates with exposures of 20^s, 1^m, 3^m, and 9^m. For examination corresponding pairs

of negatives were mounted together on a measuring machine supplied with an additional microscope, so that the observer might look quickly from one plate to the other in comparing the details photographed with the two instruments. The magnification was adjusted to bring the image of the 60-inch plate to the same scale as that of the 100-inch.

Extended masses of nebulosity show the same density, as was to be expected since the two instruments are of the same focal ratio. But in resolution, a glance is sufficient to show the superiority of the 100-inch over the 60-inch, even in the case of M 8, photographed at a zenith distance of 60° with seeing as low as 3.

The results for the 100-inch Hooker telescope in the case of N.G.C. 7009, photographed at zenith distance 46°, seeing 6, are very much the superior of the two. Fine details are clearly shown which cannot be traced on the 60-inch negative, or at most are only suggested by irregular and undefined masses of silver grains. It is noteworthy, too, that small details approximating star images in size, such as the ansae, are stronger on the 100-inch negative than on the 60-inch, altho the relatively large central part of the nebula is strictly comparable in density on the two negatives.

Greater resolution is of course to be expected from the larger instrument because of the increase of scale in the ratio of 10 to 6, provided the linear increase in the excursions of the optical image does not nullify the advantage thus derived. These tests show conclusively that there is a decided gain in resolution with seeing as low as 3 on a scale of 10.

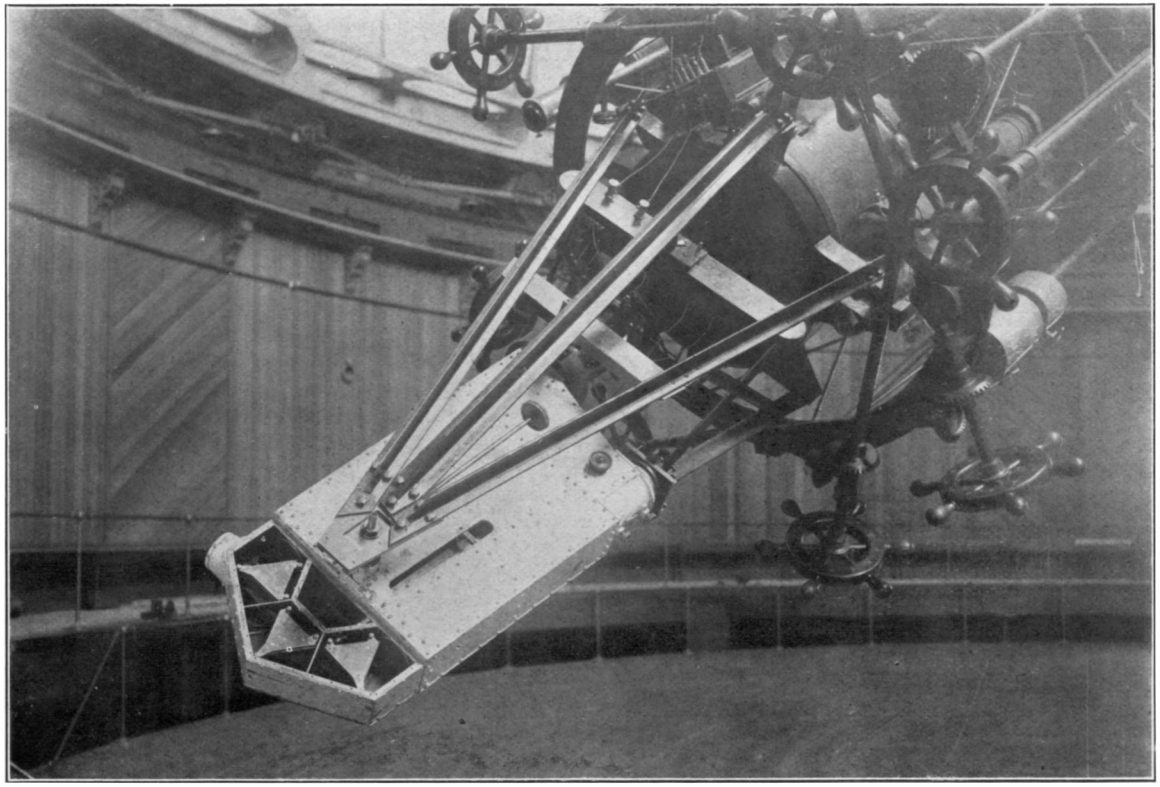
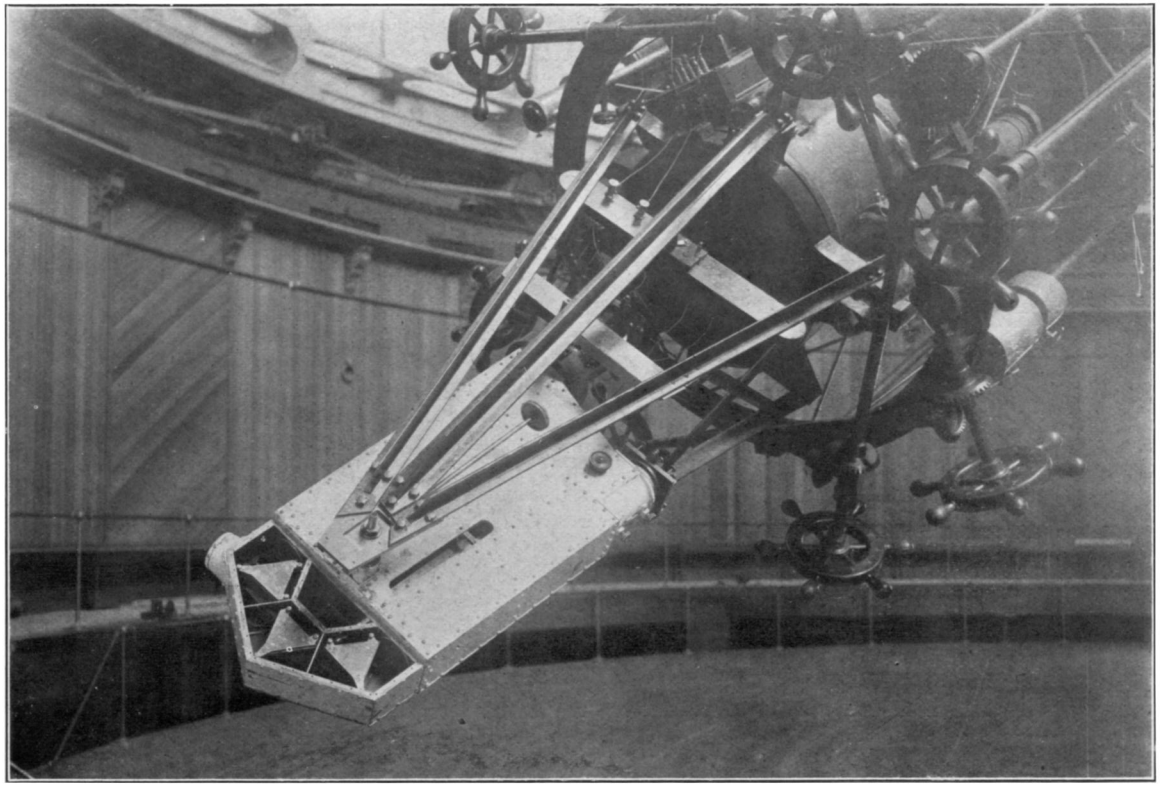


PLATE I. The New Mills Spectrograph



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